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CONTENTS

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FIELD FILLING OF PALLET BOXES NOT RECOMMENDED FOR IRISH POTATOES

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INTRODUCTION

Pallet boxes are used for the storage of Irish potatoes by some growers and processors in all of the major potato-growing areas of the United States. Although pallet box storage is more costly than bulk storage of potatoes there is, nevertheless, a great deal of interest in box storage and handling, because of certain inherent advantages in the use of boxes where the potatoes are re-handled for conditioning before processing into frozen french fries, granules, flakes, and chips. For these uses it is necessary to raise the temperature of the potatoes for a short period of time before processing in order to decrease the amounts of reducing sugars. Potatoes stored in boxes can be readily transferred from the low temperature storage to the conditioning room and later to the processing plant. Not all potatoes used for processing are handled in boxes; but, since about 20 percent of the crop in this country is processed, there is widespread interest in box storage and handling.

Nearly all users of pallet boxes for handling and storage fill the boxes at the warehouse or storage site. The use of boxes for potato handling and storage is costly. Box handling, as noted above, possesses other advantages for special purposes which probably offset the higher cost. The high cost of box handling and storage may have led to the idea that costs could be markedly reduced and injury prevented by substituting field filling directly from the harvester for yard filling. To accomplish field filling of the boxes without excessive injury to the tubers would require the development of special equipment and methods. Without modification, the existing commercial potato harvesters are not well adapted to direct filling of pallet boxes.

Objective

This study was initiated for the purposes of evaluating methods for filling pallet boxes with potatoes directly from the harvester, and developing methods and equipment for field filling of one-ton pallet boxes without excessive injury to the tubers, if the evaluation indicates that field filling operation has economic merit.

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Procedure

The first phase of this study was the development of an accurate estimate of the potential advantage that might be obtained before developing methods and equipment for field filling of pallet boxes on an experimental basis. Any method of field filling pallet boxes that might be developed would have to possess advantages in cost or decrease in injury to the product before it could replace box filling methods currently in use.

Two operators who use pallet boxes with field filling were visited in 1958 when they were harvesting their crops. One of the growers uses boxes for storing and handling potatoes; the other uses boxes for onion storage and handling. The methods used by both operators are similar in that the boxes are filled directly from the harvester with the boxes in place on the truck or trailer on which they are transported to the storage site.

Other conceivable methods of box filling in the field have been considered. It is possible that a potato harvester could be modified in such a manner that a box could be carried on the harvester while being filled and transferred to a transport truck or trailer when filled, or transferred to the ground and later picked up and placed on a truck for transport to the storage site. This system would eliminate the necessity of keeping the harvester and truck in register. However, costly equipment and extra personnel would be required for transferring the empty boxes to the harvester and the filled boxes to transport trucks.

Because of the high cost of equipment capable of handling one-ton boxes any system worthy of serious consideration must provide for filling the boxes directly from the harvester with the boxes in place on the transport vehicle. The following analysis compares this system of field filling of boxes with yard filling in respect to (1) personnel requirements, (2) equipment costs, and (3) damage to the potatoes. This analysis is limited to boxes of approximately one-ton capacity with six boxes carried on a flat-bed truck for field filling. The yard filling operation with which comparisons are made makes use of bulk self-unloading truck boxes of approximately 6-ton capacity (120 cwt.). Whether in pallet boxes or a bulk truck box the same amount of potatoes would be received at the storage with each truckload.

The method of yard filling pallet boxes, which is considered in this analysis, is a conventional practice. The potatoes are received from the harvester into a self-unloading bulk hopper body truck for transport to the storage. At storage the truck is backed into position for unloading into the hopper of a second trough belt conveyor. An electric motor is then mounted on the hopper body to drive the self-unloading conveyor. The potatoes are conveyed by the trough belt conveyor into the 1-ton pallet box in position on the box tipper. The position of the box being filled is regulated so that there is practically no drop of potatoes

from the trough conveyor into the box. Three sections of roller conveyor for holding empty boxes are located on one side of the box tipper. Two sections are located on the other side of the box tipper for receiving the filled boxes. A forklift truck is used for placing the empty boxes on the roller conveyor and removing the filled boxes and placing them in storage.

The method of field filling considered involves filling the 1-ton boxes in place on the flat-bed truck with which the filled boxes are transported to the storage site. There the boxes are removed from the flat-bed truck and placed in the storage building with the use of a forklift truck which is also used for placing empty boxes on the flat-bed truck for return to the field.

A commercial operation in which boxes are filled in the field directly from the harvester is shown in figure 1. The two-row 1958 model commercial potato harvester shown in this photograph was modified by the owner for filling 1-ton pallet boxes carried on a flat-bed truck. The bulk loader was shortened and turned to deliver potatoes to the rear of the machine on to a horizontal belt conveyor. This conveyor, driven by a hydraulic motor, is movable so that boxes on both sides of the truck can be filled without any change in the distance between the lines of travel of the truck and the potato harvester. A canvas chute, attached to the discharge end of the conveyor and manipulated by the man perched on top of the boxes, is used to check the free fall of the potatoes.

FIGURE 1.--A commercial operation of field filling of one-ton pallet boxes directly from the potato harvester.

LABOR REQUIREMENTS

The same number of workers is required for harvesting and field filling and placing pallet boxes in storage as is required for harvesting, filling the boxes at the warehouse, and placing them in storage.

A minimum of three workers, including the driver of the transport truck, is required at the warehouse for efficient yard filling operations. One man operates the forklift truck and another manipulates the box tipper and operates the self-unloading conveyor in the bulk truck box. The truck driver removes and replaces the pull-boards that cover the unloading conveyor in the bulk truck box. The box tipper operator utilizes time between truck loads to clean up soil and other tare material that drops from the potatoes as they are transferred from the bulk truck box to the pallet boxes. If time permits the forklift truck operator assists with the clean-up.

One worker at the storage can be eliminated when the boxes are filled in the field. The box tipper is not used and there is little soil to clean up between loads. This reduction in personnel at the warehouse is offset, however, by the requirement of another worker in the field to manipulate the equipment for conveying potatoes into the boxes. In few instances where boxes have been filled in the field the equipment operated by this extra worker consisted of a canvas chute attached to the end of the bulk loader. It is conceivable that more elaborate and effective equipment for limiting tuber damage could be developed for this purpose but it seems very unlikely that it would be possible to dispense with an operator for the equipment. Remote controls positioned for use by the harvester operator could theoretically eliminate the need for an operator of the mechanism used for lowering the potatoes into the boxes. It is doubtful, however, if the control of the box filling equipment could be efficiently handled by the harvester operator in addition to the other multiple operational functions for which he is responsible. This may be a moot question but it is not necessary to resolve it since the cost of such equipment would make its use uneconomical. This fact is brought out in the following section, in which equipment costs are analyzed.

Another consideration is the efficiency of handling the boxes at the warehouse associated with each method of filling the boxes. Six 1-ton boxes can be filled by using a good system with a box tipper for filling at the warehouse from a bulk truck box and the boxes placed in storage in less time than six filled boxes can be removed from a flat-bed truck, placed in storage, and six empty boxes placed on the truck and secured in place. This statement is based on the use of only one forklift truck with each method. Three factors are involved in this relationship of maximum receiving rates of the two methods as follows:

(1) Six boxes can be filled from a self-unloading bulk box in less time than is required for the forklift truck handling of the filled and empty boxes. The unloading rate of the self-unloading bulk box is, therefore, not the limiting factor in the maximum receiving rate for yard filling operations.

(2) The use of three sections of roller conveyor for handling empty boxes with the box tipper and two sections for holding filled boxes enables the forklift operator to make maximum use of any intervals between loads of potatoes for taking the filled boxes into storage and placing empty boxes on the roller conveyor.

(3) The box tipper, trough conveyor, and roller sections can be located in relation to the storage for the most convenient handling of boxes with the forklift truck whereas the field filled boxes have to be handled from both sides of the flat-bed transport truck. Moreover, the placement of the empty boxes on the flat-bed truck is more exacting than the placement of the empty boxes on the roller conveyor. The result is that more time is required for the forklift truck handling of the boxes with field filling than for yard filling operation and consequently the maximum receiving rate of the latter method is higher.

If the actual harvesting rate is lower than the maximum receiving rate for field filled boxes, the comparative receiving rates of the two methods is not an important consideration in favor of one method or the other. It should be borne in mind, however, that field filling of pallet boxes offers no advantage over yard filling in respect to personnel requirements or labor efficiency.

A COMPARISON OF EQUIPMENT COSTS

In order to make a comparison of equipment costs between yard filling and field filling of pallet boxes it is necessary to include in the analysis all functions from harvesting, through transporting to the storage site, placing in storage, and removing from storage. This is true because of the altered relationships of the functions involved in the two systems of box filling.

For determination of overall equipment costs it is not necessary to divide the costs among the functions of harvesting, transporting, placing in storage, and removing from storage. For instance, a box tipper is used for yard filling operations and also used for emptying boxes when removing the potatoes from storage. For this analysis it is not necessary to subdivide the ownership costs between the two functions. The box tipper is not used for handling field filled boxes into storage but the ownership costs remain the same because this unit is required for emptying the boxes when removing the potatoes from storage. This latter function must, therefore, be included in the overall comparison of equipment costs for the two systems of box filling.

It is not necessary to determine or assume costs for the items that are equal for both systems. The truck cost is one such item. The cost of transportation from the field to the warehouse would depend on the distance but would presumably be the same whether a given load of potatoes is transported in 1-ton pallet boxes or in a bulk box.

Table 1 is a condensation of a detailed cost analysis for each item of equipment involved in both yard filling and field filling of 1-ton pallet boxes. The annual cost of each item was determined. This figure includes ownership and operating costs. Ownership costs include depreciation, interest at 5 percent based on one-half of the initial cost, and insurance and taxes at 4 percent. Operating costs include repairs, maintenance electrical energy, and fuel. The total annual cost as thus determined for each item was divided by 350 (the number of truckloads to fill a 42,000 cwt. capacity storage) to arrive at the cost per truckload of 120 cwt.

No cost figures for the harvester is shown in Table 1. The difference in cost between the two methods of box filling would be determined by the cost of the modification of the harvester and added equipment necessary for filling boxes in the field. The "Total" figure of -$0.20 for the last column in Table 1 indicates the size of the cost margin for these modifications and added equipment. This is the difference in equipment costs per truckload of potatoes before making any allowances for special equipment for field filling operations. If we assume an 8-year life, interest at 5 percent on one-half of the initial cost, insurance and taxes at 4 percent, and maintenance and repairs at 4 percent, there is a margin of $304.35 for harvester modifications and special equipment. If this cost exceeds $304.35 then the equipment costs for field filling of pallet boxes will exceed the equipment costs for yard filling operations. Any kind of elaborate equipment for lowering the potatoes into the boxes would raise the equipment costs for field filling operation markedly above the equipment costs for yard filling methods currently in use. If, for instance, the price of special equipment for field filling amounted to $1,526.10, then equipment costs per truckload would be $1.00 more than for yard filling. As shown in the preceding section on labor requirements there is no prospect of offsetting higher equipment costs with a reduction in labor costs.

As shown in Table 1 there is only a moderate reduction in equipment required at the warehouse when field filling is substituted for yard filling of pallet boxes. The largest items eliminated at the warehouse by field filling are the trough conveyor and three roller conveyor sections. The most expensive items of equipment required for handling boxes are the forklift truck and the box tipper. These are not eliminated by substituting field filling of the boxes for yard filling. It is true that the box tipper could be dispensed with if a forklift truck with a rotating head is used but the additional cost of the rotating head and increased breakage of pallet boxes would offset the elimination of the box tipper.

Table 1.--Equipment Costs For 1-Ton Pallet Box Handling and Storage of Potatoes in a 42,000 Cwt. Capacity Storage Building. A Comparison of Costs Between Yard and Field Filling of the Pallet Boxes[1]

Equipment Description	Intial Cost per Unit	Units required		Cost per truckload of 120 Cwt.		
		Yard filled	Field filled	Yard filled	Field filled	Difference
	Dollars			Dollars	Dollars	Dollars
Harvester	---	1	1[2]	---	---	(2)
Truck	(3)	3	3	---	---	(3)
Flat bed	300.00	-	3	---	.22	+.22[4]
Bulk Box	620.00	3	-	.79	---	-.79
Motor For Hopper Body	100.00	-	-	.04	---	-.04
One-Ton Boxes	14.00	2100	2100	9.04	9.95	+.91[5]
Trough Conveyor	600.00	1	-	.25	---	-.25
Roller Conveyor (4' Sect.)	141.40	5	2	.30	.12	-.18
Box Tipper	964.00	1	1	.44	.40	-.04
Forklift Truck	5355.00	1	1	2.22	2.22	---
Wheelbarrow	25.00	2	-	.02	---	-.02
Shovel	4.00	2	-	.01	---	-.01[6]
Total						-.20[7]

[1]This differential cost analysis takes into consideration the combined functions of harvesting, filling pallet boxes, transporting to storage, placing in storage, and taking out of storage. Except as otherwise noted below, depreciation costs were computed on a basis of 15 years' life expectancy. The difference in the last column is the cost per truckload for field filling equipment minus the cost for yard filling equipment.

[2]Harvester costs for both systems are the same if the cost of special equipment for field filling of boxes is disregarded. All items for which costs are indicated are commercially available.

[3]Truck costs depend on transportation distance. For a given distance truck costs cancel out.

[4]Operating cost computed at 3/4 of 1 percent per 100 hours of use; 50 percent of ownership costs allocated to other uses.

[5]The difference in the cost of boxes is due to the assumption of reduced box life for boxes filled in the field (25 years vs. 20 years) and increased operating costs. Repair cost for yard filled boxes is computed at 3-3/4 cents per year per box. For field filled boxes the repair cost is computed at 5 cents per box.

[6]Depreciation based on 3 years' life expectancy.

[7]This is the difference in equipment costs for the two methods without taking into consideration the cost of providing special equipment, which is not commercially available, for field filling of pallet boxes. This marginal difference in favor of field filling operation would be eliminated if special equipment for delivering potatoes into boxes cost as much as $.20 per truckload.

The cost of the pallet boxes is the largest item in the use of boxes regardless of where they are filled. In computing box costs it was assumed that the boxes would be subject to more rough handling when filled in the field and the box life would consequently be reduced as compared with boxes filled at the warehouse. It seems that life expectancies of 25 years and 20 years are reasonable for yard-filled and field-filled boxes, respectively.

TUBER INJURIES

Pallet boxes can be filled at the warehouse with very little injury to the tubers. In 1953 and 1956, 1-ton pallet boxes were filled at the research center with only 0.2 percent grade defects.

No system of box filling can undo the injury that occurs on the harvester between the digger blade and the end of the bulk loader. By exercising care in control of the bulk loader, potatoes can be loaded into a bulk hopper body truck with practically no damage due to dropping from the bulk loader. This requires coordination between the truck driver and the harvester operator in order that loading may be accomplished in a manner that prevents excessive roll-down of the potatoes. The harvester operator must also be alert in regulating the bulk loader to minimize the distance that the potatoes are dropped.

Filling boxes in the field would not make the harvester operator's job any less exacting. In fact, the coordination between the harvester operator and the truck driver would be even more exacting because of the reduced limits for maintaining the harvester and the individual pallet box in register.

Since boxes can be filled at the warehouse with damage amounting to as little as 0.2 percent grade defects, it is apparent that there is a very narrow margin for improvement in this respect. If the damage could be reduced to one-half of this amount, the saving would amount to only 12 pounds of potatoes per truckload. If the value of 12 pounds is assumed to be 18 cents, additional equipment to accomplish this reduction in injury cannot be justified if the cost exceeds $273.91. This figure is based on a life of 8 years, interest at 5 percent, taxes and insurance at 4 percent, and repairs and maintenance at 4 percent.

DISCUSSION

In the three preceding sections labor requirements, equipment requirements, and injury losses were separately analyzed, in comparing pallet box filling methods. The results of these separate analyses may be summarized as follows:

1. There is no prospect of reducing labor costs by substituting field filling for yard filling operations with 1-ton pallet boxes.

2. There is a very thin cost margin (1/6 cent per cwt.) in respect to equipment for development of harvester modifications for filling boxes in the field.

3. Pallet boxes can be filled at the warehouse with little damage to the potatoes. Therefore, elaborate equipment for lowering the potatoes into the boxes in field filling operations cannot be justified on the basis of reduction of injury to the potatoes.

It was shown in the section on comparative equipment costs for yard filling of boxes and field filling operations that additional equipment for field filling with an initial cost of $304.35 would eliminate the margin in favor of field filling in respect to equipment costs. It was further shown in the discussion of injury that elimination of 50 percent of the injury associated with yard filling operations would only justify additional equipment costs of $273.91. The total of these two figures ($304.35 and $273.91) is $578.26. In other words, if the price of the special equipment used for field filling of pallet boxes amounted to $578.26, and if the damage is reduced from 0.2 to 0.1 percent grade defects, and if there is no reduction in labor efficiency, there would be no economic advantage of one system over the other.

The above example is based on some extremely dubious assumptions. The only reason for using it is to illustrate the low cost limit placed upon the development of special equipment for field filling of pallet boxes. Obviously this limit precludes the possibility of using any elaborate equipment for reducing damage in lowering potatoes from the harvester into the boxes, so there is little possibility of even limiting damage to the potatoes to the low figure of 0.2 percent grade defects attainable with yard filling of pallet boxes. It is an equally remote possibility that potatoes can be harvested into boxes without some reduction in harvesting efficiency. The cost limitation on the equipment for lowering potatoes into boxes precludes the possibility of the development of equipment which would not require that the harvester and transport truck be kept in register. This requirement of more exacting coordination between the truck driver and the harvester operator could easily result in a slower rate of travel. To illustrate the importance of even slight reduction in harvesting efficiency the following example is cited:

> *The total number of personnel is the same for yard or field filling of pallet boxes. Truck drivers, the tractor driver, the harvester operator, workers on the harvester, and warehouse workers, for example, might make a total of 11 people paid at an average rate of $1.25 per hour. If 24 truckloads of 120 cwt. are harvested per day into a bulk hopper body truck but only 23 loads can be harvested into pallet boxes, the reduction in harvesting efficiency will increase labor costs from $5.73 to $5.98 per truckload. This amounts to $87.50 per year for increased labor costs in filling a storage of 42,000 cwt. capacity.*

Even if the most optimistic estimates for reduction of cost by substituting field for yard filling of pallet boxes could be realized, the marginal difference would be so slight that the reality of any saving would be difficult to establish for a commercial operation. It is highly improbable that boxes can be filled in the field without incurring costs of at least 57 cents per truckload in excess of the overall costs for box handling and storage when an efficient yard filling operation is conducted. This statement is based on the following estimates:

(1) A cost of $800 for modifying the bulk loader of a potato harvester for use with a canvas chute for lowering potatoes into the boxes. This addition would increase equipment costs by 52 cents per truckload and make equipment costs for the field filling operation 32 cents per truckload greater than for yard filling operations.

(2) A 4 percent reduction in the harvesting rate for field filling operation as compared to yard filling of pallet boxes. This would add 25 cents per truckload for labor costs.

This estimated difference in costs does not allow for any increase in injury for field filling operation. Some increase in injury seems probable. The difference in injury that might occur is difficult to estimate and would depend to a large degree on the skill exercised in manipulating the canvas chute.

Even if we assume that the damage to the tubers due to the box filling operation could be completely eliminated by the development of special equipment for lowering the potatoes into the boxes, the apparent economic factors involved do not justify any efforts to develop such equipment for field filling of pallet boxes.

CONCLUSIONS

1. There is no prospect of reducing personnel requirements or increasing labor efficiency by substituting field filling of pallet boxes for yard filling operation.

2. Considerations of equipment costs, injury to the potatoes, and harvesting efficiency, indicate that pallet boxes can be filled more economically at the storage than in the field. Commercial equipment is available for yard filling of pallet boxes.

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